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Recycling of spent mushroom substrate to vermicompost

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ABSTRACT

Investigations were made to recycle spent mushroom substrate (SMS) for the production of vermicompost using earthworms (*Eisenia foetida*). Spent mushroom substrate (SMS) was obtained after harvesting mushroom grown on coffee industry wastes. This Spent mushroom substrate has a fibrous material content, which improves soil physical properties and biological activity. Different combinations of spent mushroom substrate, cowdung and farmyard manure were tried for vermicomposting. Maximum growth and cocoons production was recorded in vermireactor containing cow dung and SMS. The C/N ratio of vermicompost reduced to 9:35 from 52:2. The nutrient composition of the vermicast thus produced was of good quality. Based on investigations it is concluded that recycling of SMS generated after utilizing coffee wastes can be potentially used as a raw material for vermicomposting. Recycling/waste management of Coffee industry wastes (primary) to Spent mushroom substarate (secondary wastes) and further to vermicompost is reported from our findings. The transition from chemical nutrition to bionutrition can be sustained with out affecting the ecological processes.

KEYWORDS

Vermicomposting;
Eisenia foetida;
Coffee industry waste;
Cowdung;
SMS;
C:N ratio.

INTRODUCTION

Our urbanized and industrialized society is producing large quantities of biological wastes and increasing demand for disposal mechanism to be environmentally compatible and sustainable is very essential. Wastes of animal and plant origin are one of the major under-utilized resources in many countries. Although various physical, chemical and microbiological method of disposal of organic solid wastes are currently in use, these wastes could not be fully exploited due to the non-availability of a viable technology for their economic recycling. Earthworms in dense culture and large quantities can physically handle most biological waste and potentially at the fraction of the cost of conventional methods of waste management.

Many organic wastes have been converted into vermicompost by different species of earthworms which include cattle dung, horse waste, mango leaves, turkey waste, water hyacinth, paper waste, industrial sludge, Coffee pulp and solid paper mill sludge,sheep manure, spent mushroom waste[1,2,17,19,20]. Coffee industry wastes (primary waste) are well used for growth of mushrooms and thus generated spent mushroom substrate(secondary waste) is of large quantity[21]. Spent mushroom substrate (sometimes called mushroom soil, recycled mushroom compost, or mushroom compost) is the composted organic material remaining after a crop of mushrooms is harvested. After the mushrooms are harvested, the "spent" substrate is removed from the houses and pasteurized with steam to kill insects, pathogens, and mushroom remnants. The appearance of dried SMS is similar to peat, with a light brown color, light, fibrous texture and contains nutrients like nitrogen phosphorus, potassium, calcium and magnesium.Although there is some information on the spent mushroom substrate for production of vermicompost from organic wastes, there is no research evidence on utilization of the SMS obtained from coffee industrial wastes. Hence, investigations were carried out to convert secondary organic substrates such as SMS along with Cow dung and farm yard manure into value added worm meal/ vermicompost using *E.foetida*. A complete recycling of primary and secondary wastes is explored.

MATERIALS AND METHODS

E.foetida

Healthy adult earthworms commonly known as tiger wigglers i.e. *Eisenia foetida* weighing between 0.5-0.7g were randomly picked up for the experiment from stock culture maintained by Central Sericulture Research and Training Institute, Mysore, India.

Substrates

Spent Mushroom Substarte (SMS) was collected after the cultivation of mushroom using coffee industry waste as substrates in our laboratory[21]. Farmyard manure (FYM) and Cow dung (CD)) was procured from the Horticulture dept., Mysore, India. The composition of the SMS, FYM and CD is used for vermicompositing is presented in TABLE 1.

All the organic wastes were used on dry weight basis by oven drying at 110^{0}C to constant mass.

TABLE 1: Composition of SMS, FYM and CD used for vermicompositing

Parameters	SMS(%)	FYM(%)	CD(%)
Total Nitrogen	1.95	73.0	0.3
Total available phosphorus	0.5	0.4	0.6
Total potassium	0.4	0.74	0.28
Total calcium	3.6	1.98	2.23
Total carbon	3.6	9.98	47.3
C: N ratio	3.1	14.1	47:1

Vermicomposting

Vermicompositing was conducted during September-December, 2006 at CFTRI, Mysore,India. Five-vermireactors weighing 100g (dry weight basis) with different combinations such as 1.FYM, 2.CD, 3.SMS, 4.FYM+SMS-50:50, 5.CD+SMS-50: 50,were used for vermicompositing. *E.foetida,* ten in numbers weighing approximately 0.5-0.7g were placed in vermireactors to provide optimal sticking density as 100-200mg/g body wt/day[11]. The moisture content was maintained at 70$\pm$10% of water holding capacity by periodic sprinkling of an adequate quantity of water. All the containers were kept in dark under identical conditions (temp. 25$\pm$3^{0}C, relative humidity, 60-80%). The experiments were done in triplicates. One set of each feed was maintained without worms, as control. The weights of the earthworms were taken periodically. After the feed material was converted to loose granular mounds due to feeding and defecation by the worms, the sprinkling of water was stopped to lower the moisture content of the vermicompost. During the experimental period (90days) the total number of earthworms and coccons were sorted by hand sorting for weighing and counting periodically. The vermicompost produced was air dried at room temperature and packed in airtight container for further analysis.

Chemical analysis

Total organic Kjeldhal nitrogen was determined by digesting the sample with conc. H_2SO_4 and $HClO_4$ (9:1v/v)[3] Total phosphorus (TP) was analyzed using the colorimeter method with molybdenum in sulphuric acid, total Potassium (TK) was determined after digesting the sample in di-acid mixture (concentrated HNO_3: concentrated $HClO_4$ 4:1v/v), by flame photometer (Elico, CL 22D, India[4]). Total organic carbon was determined using potassium dichromate titration method[16]. Micro-nutrients were determined by atomic absorption spectrophotometer (AAS) (AAS 414, Electronic corporation of India, BLL 0.001mg/l) after digesting the samples with Conc HNO_3 and Conc $HClO_4$ (4:1V/V)[18]. The pH and moisture content of the samples was measured as described by[14,24]. All chemical were of analytical reagent (AR) grade from standard companies. All the samples were analyzed in triplicates and result were averaged.

RESULTS AND DISCUSSION

During the experimental period the worms grew well in vermireactors. Figure 1 shows the growth pattern of *E.foetida* in different vermicomposter with time. These species of earthworm were selected due to its tolerance to wide range of temperature and high metabolic rate[10]. Maximum earthworm biomass was observed in combination comprising of cow dung and spent mushroom waste. Maximum worm biomass was attained in the 8th week and gradual decrease in biomass was recorded in all vermicomposters. It may be due to the exhaustion of worm feed in vermicomposters. When *E.foetida* reclaimed food below a maintenance level, it lost weight at a rate, which depended upon the quantity and nature of its ingestible substrates[15]. However, there was no linearity in increase in the number of worms in the combinations used.

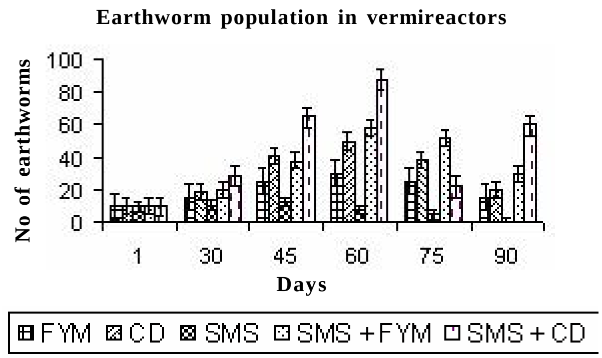
The quality and amount of food materials influences not only the size of earthworm population but also the species present and their rate of growth and fecundity[5,7]; *E.foetida* are characteristic to have more metabolic rate, high conversion and production rate and are more useful for vermicompost.

Nutrient content of vermicompost

The spent mushroom biofertilizer was obtained from earthworm, which carries a bioprocess in converting the spent mushroom waste grown on coffee industry waste into organic manure. The vermicompost was much darker black in colour and homogeneous after 90 days of earthworm activity, whereas the material without earthworms remained in compact clumps. The colour of the vermicompost varied in the combinations used. The colour of typical vermicompost i.e. black was observed with combination of SMS and cow dung. In all

TABLE 2: Nutrient composition of the vermicompost

Parameter	CD+SMS	FYM+SMS
Moisture	65%	62%
PH	7.0	7.1
Colour	Black	Sl.Brownish
Nitrogen	2.02 %	2.03 %
Phosphorus	0.21 %	0.15 %
Potassium	0.45 %	0.32 %
Organic carbon	18.9 %	17.0 %
C:N	9.35 %	9.11 %
Zn	65.3 ppm	50.1 ppm
Cu	30.3 ppm	22.0 ppm
Mn	37.0 ppm	23.0 ppm
Fe	2750 ppm	2100 ppm



*FYM-Farm Yard Manure, CD-Cow Dung, SMS-Spent Mushroom substrate

Figure 1: Earthworm population in vermireactors at sampling time

other combinations tried, the colour was not very dark compared to cow dung and SMS the combination with Farmyard manure and SMS was slightly brownish in colour. The pH of the SMS and cow dung was 7.0 and the FYM and SMS combination was 7.1. The moisture of the SMS & Cow dung combination was 65% whereas the FYM and SMS was 62%. The analysis of the vermicast of combination with Cow dung and SMS showed 9.35 in C: N ratio compared to the 70.8 starting material (TABLE 2). There was an increase in nitrogen and organic carbon but a decrease was observed with phosphorus, potassium and nitrogen. There was a 7.5% fold decrease in C: N ratio in the vermicast.

With the rapid development and expansion of coffee industries, cultivation of mushroom using these wastes can generate of large quantity of SMS. These waste materials form pretreated materials for vermicompost. Various agricultural, horticultural, animal wastes, silkworm litter, weeds, kitchen waste, city refuse, spoilt food etc., have been used for vermicom post[12].

Pig manure was pretreated for vermicomposting by *E.foetida*[6]. *E.foetida* has been successfully used in sludge management[13], paper pulp[8] and lignocellulose waste of maple[23]. As a soil amendment, spent substrate adds organic matter and structure to the soil. In our studies, the coffee industry wastes were used for growth of mushroom (first stage) and the spent was used for vermicomposting.

Chans and Griffiths[6], reported that worms fed with untreated pig manure died within a few hours. Similarly[8], worms were unable to survive in paper pulp mill sludge. In our studies the mushroom spent with cow dung had a good number of total earthworms than farmyard manure, which significantly increased the sexual maturity and reproduction of *E.foetida*. Hence the substrate appears to be more supportive for carrying out the activity of earthworms.

Vermicomposting is an aerobic, biooxidation, nonthermophilic process that depends on earthworms to fragment, mix and promote microbial activity[9]. The process takes place at mesophilic temperatures, where the broken up organic matter is combined with soil particles. The final product is a stabilized, well-humified, organic fertilizer, with adhesive effects for soil, stimulator for plants, and most suitable for agriculture. The potential of different kinds and combinations of wastes to support the biomass of earthworm will dictate the quality of vermicast.

Our lab scale experiments of processing cow dung and SMS mixtures by earthworms provide valuable insight about the process and the changes brought about by the earthworm activity. It appears that the initial few weeks after introduction of earthworms to feed mixtures are the most critical. During this period, most of the decomposition and stabilization of feed mixtures by earthworm occurs.

Mushroom compost has a fibrous material content, which improves soil physical properties and biological activity. The C:N ratio, one of the most widely used indices for maturity of organic decreased due to decomposition. A decline of C:N ratio to less than 20 indicates an advanced degree of organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. In our studies the carbon nitrogen ratio inclusive of cow dung and spent mushroom waste, which is 52:2 decreased to 9:35 with time and activity of worms. This is well supported when compared to the C:N ratio in control (wormless vermireactor) The loss of carbon as carbon dioxide in the process of respiration and production of nitrogenous excreta may enhance the level of nitrogen, which lowers the C: N ratio.

However, the final product was more stabilized, as demonstrated by a significant decrease in C: N ratio. The use of secondary wastes i.e. spent mushroom substrate (SMS) obtained through use of coffee wastes as raw material can potentially help to convert this waste into a value-added product that is vermicompost which is a mixture of residue, all types of beneficial microorganisms, major and micro nutrients and undigested organic matter.

CONCLUSIONS

Recycling/waste management of Coffee industry wastes (primary) to grow mushrooms and the available spent mushroom substrate (secondary wastes) to further vermicompost is reported from our findings. Our investigations on harnessing vermitechnology utilizing cow dung and Spent Mushroom substrate (SMS) provide valuable insight about the process and the changes brought about by the earthworm activity. The earthworms did not feed much on SMS and has accepted it as a diet only when cow dung was spiked with it. Mixing of organic supplements such as cow dung creates suitable microcosms for the earthworms. The physical and chemical quality of the vermicompost comprising of cow dung and spent mushroom waste not only accelerated the mineralisation of nutrients but also proved a media for vermiculture. The transition from chemical nutrition to bionutrition can be sustained with out affecting the ecological processes. Hence the integration of waste utilization in diversified forms is an attractive concept.

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